5. Joseph F. Gettrust, U.S. Naval Research Laboratory

Gas Hydrate Dissociation/Generation in the Marine Environment
(Naval Research Laboratory Accelerated Research Initiative)

- Principal Investigator: J. Gettrust[+]
- Co-Investigators:
  - W. Wood[+]
  - R. Coffin[*]
  - K. Grabowski[*]
  - P. Vogt[+]
  - J. Yesinowski[*]
  - R. Lamontagne[*]
  - S. Rose-Pehrsson[*]

[+] Ocean & Atmospheric Science & Technology Directorate, NRL

[*] Materials Science & Component Technology Directorate, NRL

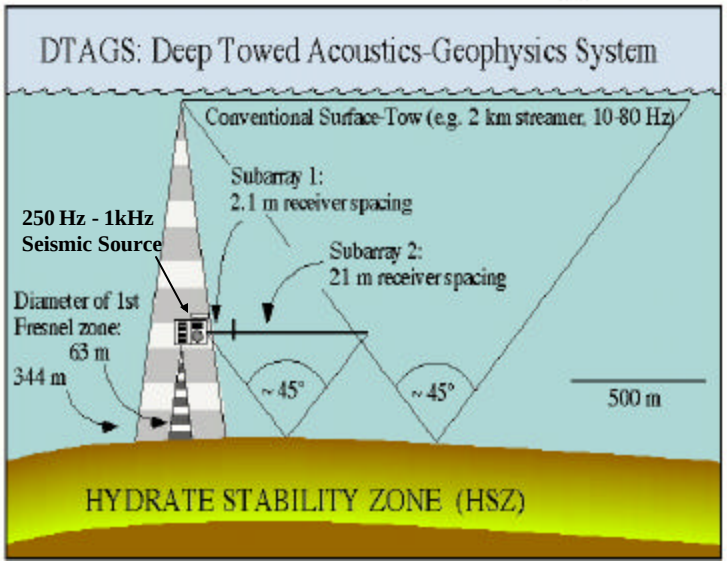
Thrust of NRL's Hydrates Accelerated Research Initiative (ARI)

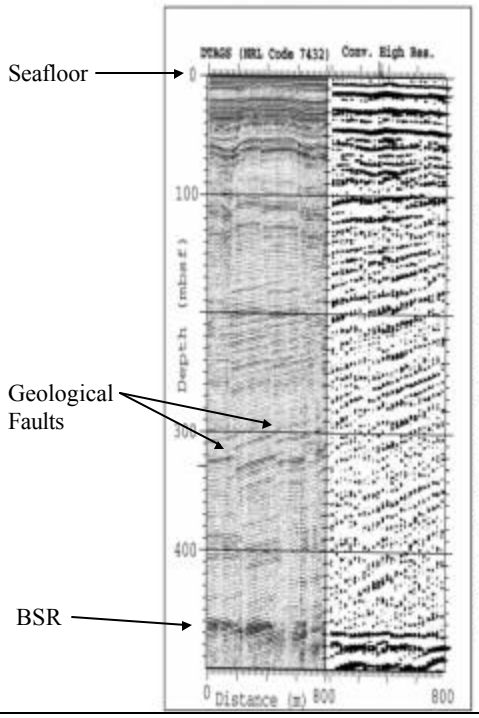
- Study Dissociation/Creation of Natural Gas Hydrates and Develop Predictive Models for Impact of this on Properties of Marine Sediments.
  - Use High-Resolution, Deep-Tow MCS to Establish Geologic Framework Through Hydrate Stability Zone.
  - Integrate NRL's capabilities in Physics and Chemistry to Quantify Age-Relationships, Processes.
    - Quantify Biogeochemical Interactions Between Hydrates & Sediments
    - Use NMR techniques to identify & image methane gas hydrates in sediment core samples.
    - Development of ***In Situ*** Methane Sensors.
    - Use Isotopic Analysis of Sediments/Hydrates to Study Hydrate Formation History.

Deep-Tow Multichannel Seismic

- Developed to study detailed geoacoustic properties to full ocean depths.
- Uses Helmholtz Resonator source to provide stable, repeatable seismic source over full depth range (0 - 6000 m).
- Deep-tow geometry increases resolution within upper 1 km+ of sediments.

DTAGS vs. Conventional acquisition



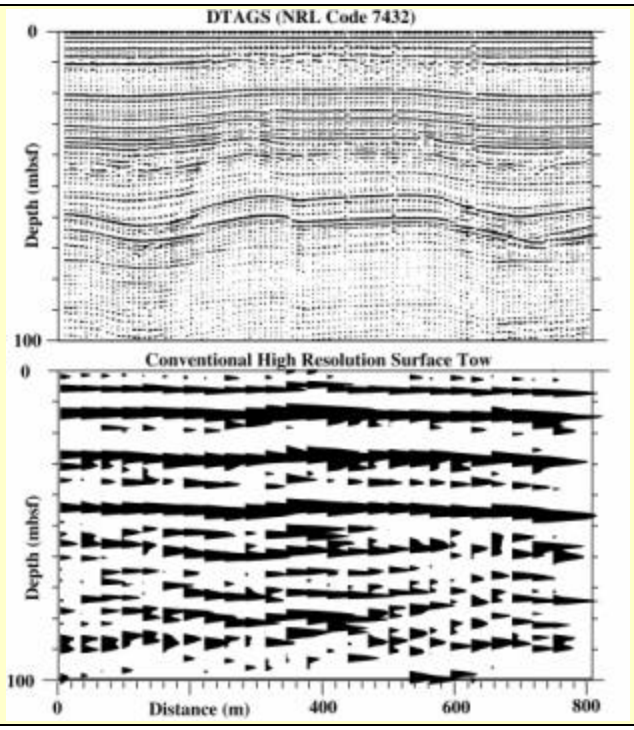


The order of magnitude improvement in both vertical and lateral resolution of DTAGS data (250-650 Hz) over conventional high-resolution single-channel air gun data data (10-220 Hz), Line 31 from Katzman et al., 1994 is clearly shown in this figure.

The very sharp images of the growth faults ubiquitous on the Blake Ridge (Rowe and Gettrust, 1994) are confirm that these faults extend through the hydrate stability zone.

The DTAGS data shown here were recorded ~1km south of the site where the Katzman et al. data were taken (near ODP Site 997).

Both of the data sets presented are converted to depth using the interval velocities from Holbrook et al., 1996 for Site 997.



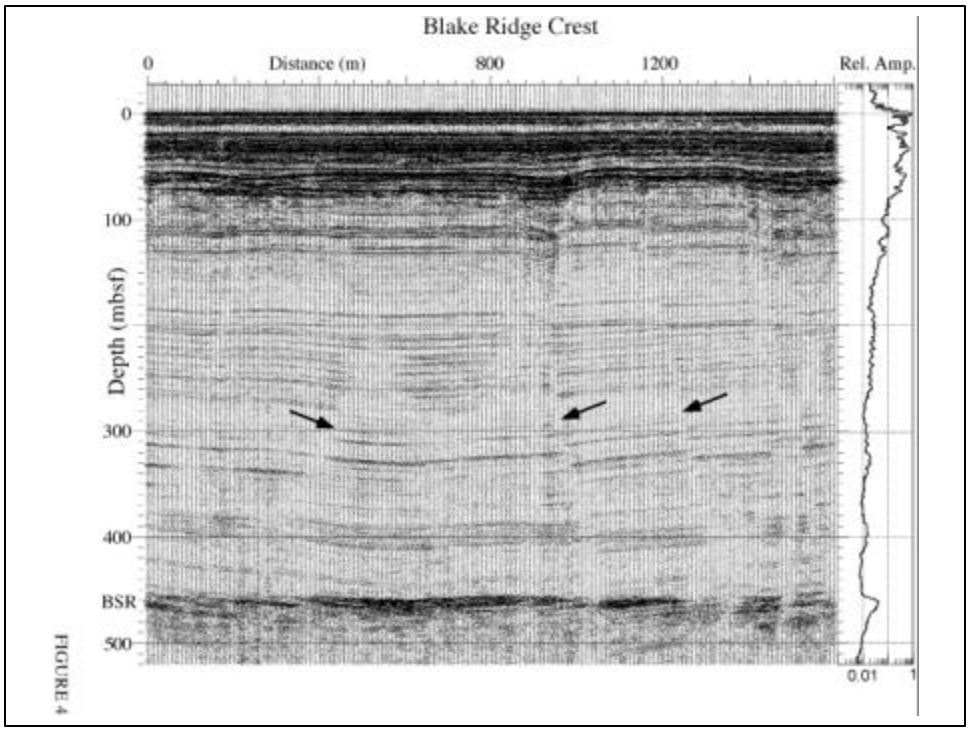
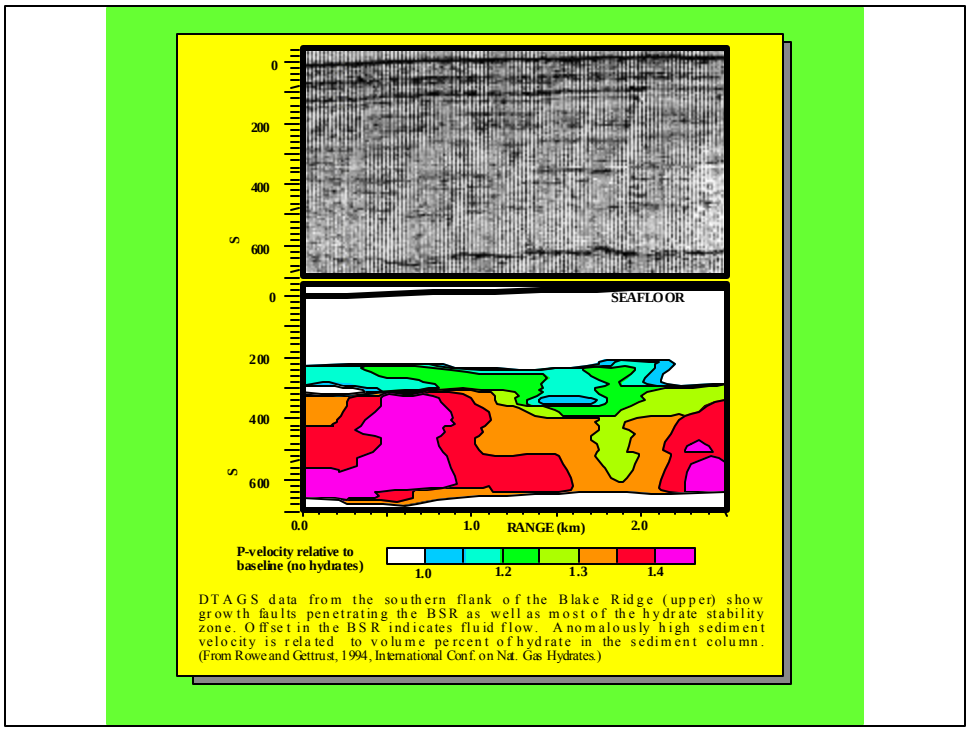
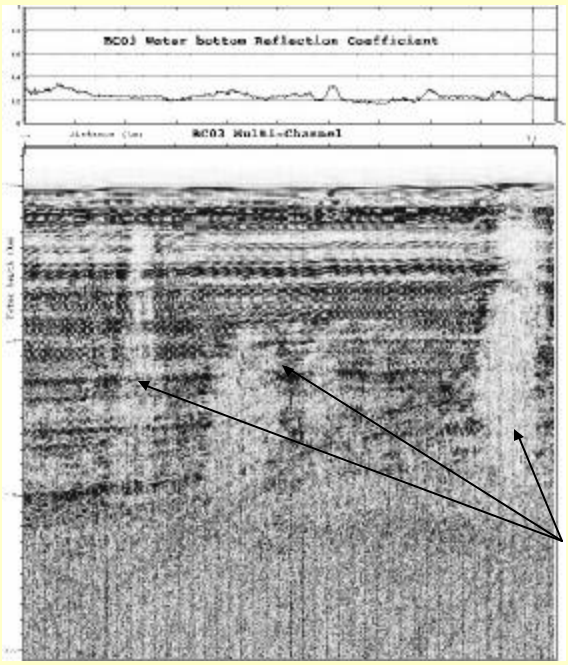


FIGURE 4



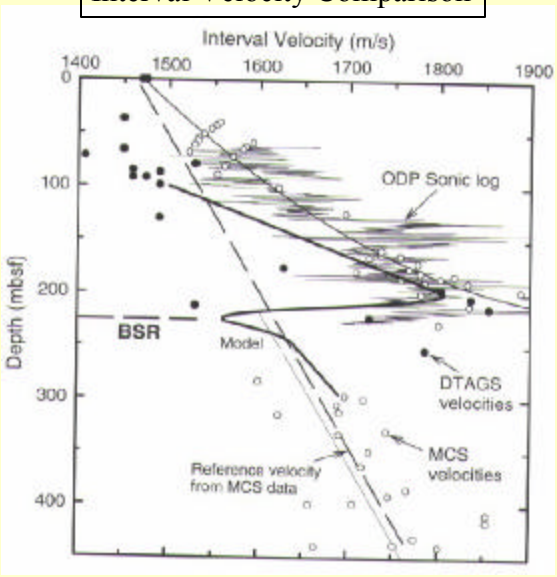
DTAGS data from the southern flank of the Blake Ridge (upper) show growth faults penetrating the BSR as well as most of the hydrate stability zone. Offset in the BSR indicates fluid flow. Anomalously high sediment velocity is related to volume percent of hydrate in the sediment column. (From Rowe and Gettrust, 1994, International Conf. on Nat. Gas Hydrates.)

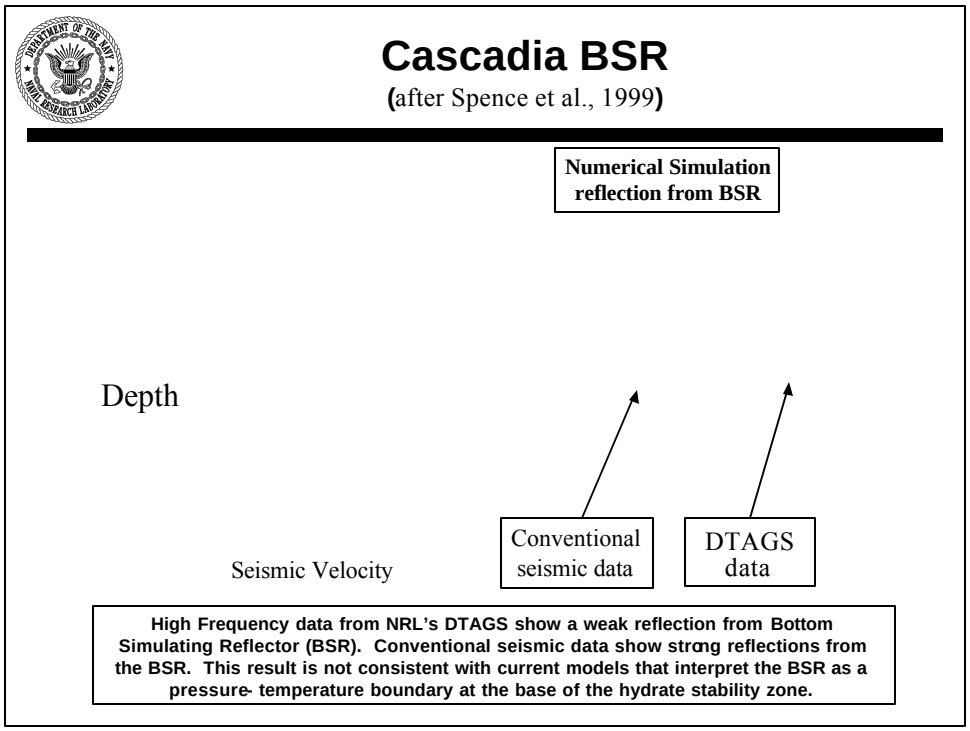


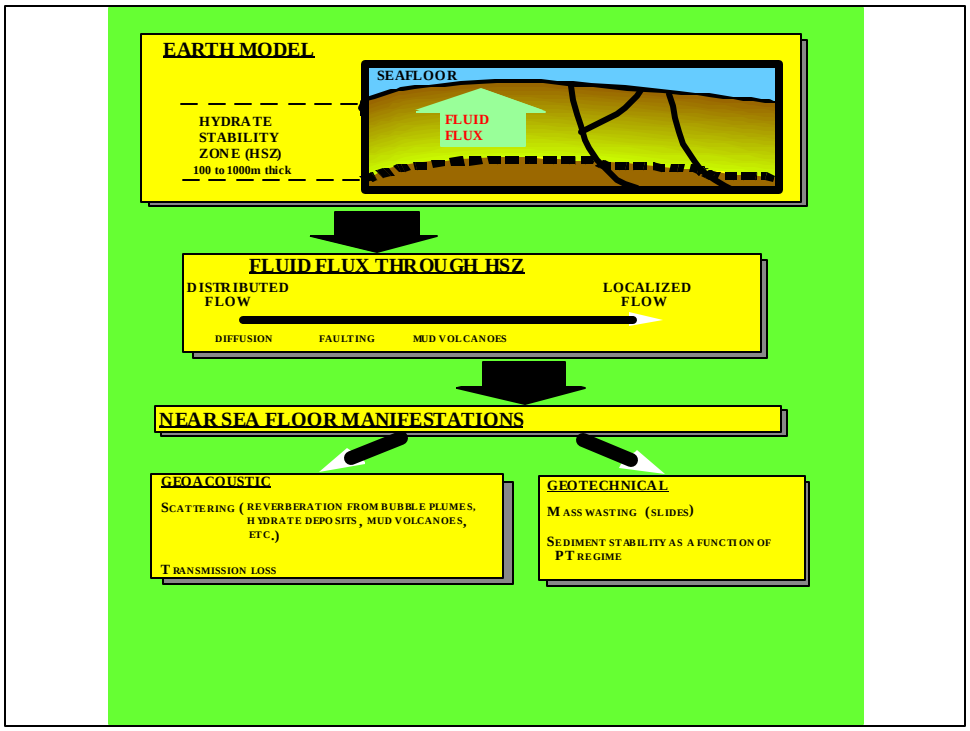
Cascadia Margin
DTAGS Data

"Wipe Out" zones related to dissociation of hydrates

Interval Velocity Comparison

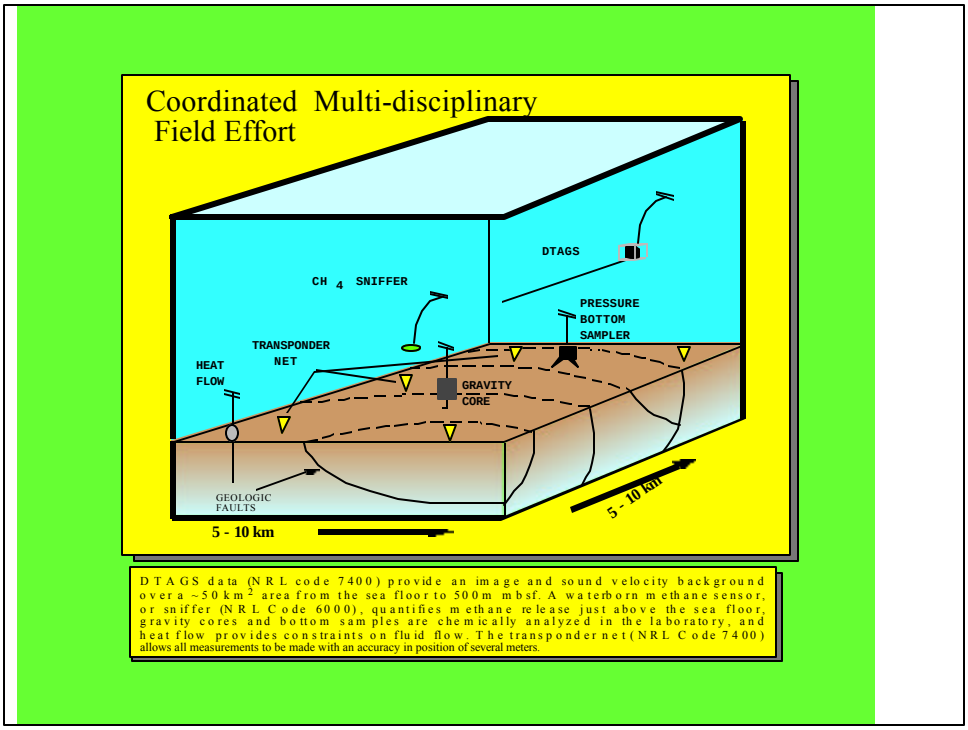



Cascadia BSR
(after Spence et al., 1999)
Numerical Simulation reflection from BSR
Depth
Seismic Velocity
Conventional seismic data
DTAGS data
High Frequency data from NRL's DTAGS show a weak reflection from Bottom Simulating Reflector (BSR). Conventional seismic data show strong reflections from the BSR. This result is not consistent with current models that interpret the BSR as a pressure- temperature boundary at the base of the hydrate stability zone.


EARTH MODEL
SEAFLOOR
FLUID FLUX
HYDRATE STABILITY ZONE (HSZ)
100 to 1000m thick
FLUID FLUX THROUGH HSZ
DISTRIBUTED FLOW
LOCALIZED FLOW
DIFFUSION
FAULTING
MUD VOLCANOES
NEAR SEA FLOOR MANIFESTATIONS
GEOACOUSTIC
SCATTERING (REVERBERATION FROM BUBBLE PLUMES, HYDRATE DEPOSITS, MUD VOLCANOES, ETC.)
TRANSMISSION LOSS
GEOTECHNICAL
MASS WASTING (SLIDES)
SEDIMENT STABILITY AS A FUNCTION OF PT REGIME

Quantification of Micro-Structure, Ages, & Geochemistry to Constrain Models of Processes

- In-Situ Sensing of Natural Gas Hydrates.
  - Adapt and/or develop instruments with increased sensitivity and sample rate.
- NMR to identify, image, and study hydrates.
  - Non-destructive, non-invasive, sensitive, quantitative tool to identify & image methane gas hydrates in sediment core samples to study structural composition and nonstoichiometry.
- Isotope Analysis to Determine Age and Origin of Hydrates and Sediment.
  - Use Transmission Electron Accelerator Mass Spectrometer (TEAMS) Consider isotopes such as $^{40}Ar/^{39}Ar$, ^{10}Be , ^{26}Al , ^{14}C, and $\delta^{18}O$.
- Biogeochemistry roles in the creation of gas hydrates.
  - Differentiate between biogenic & thermogenic sources
  - Benthic communities interaction with gas hydrates



Summary, NRL Gas Hydrates Accelerated Research Initiative

- This is a focused study to quantify gas hydrate dissociation/creation processes & rates.
- It is predicated on NRL's unique high-resolution, deep-tow MCS capabilities to resolve geologic framework.
- Exploits the broad range of expertise available within NRL to quantify micro-scale processes.
- Predict Geotechnical and Geoacoustic properties within regions where gas hydrates are found.
- ***The ARI is designed to be collaborative with entire hydrates research community***.

Coupling Between Proposed DOE Program and NRL ongoing Research/ARI

- NRL
  - Geoacoustic Properties
  - Dissociation (flux)
  - Sediment stability for bottom mounted systems
  - Numerical Simulation
- DOE
  - Resource Characterization
  - Safety & Seafloor Stability
  - Safety & Seafloor Stability
  - Production, global carbon cycle

NRL Contributions to the DOE Hydrates Program

- Collaborative NRL/USGS/DOE Studies with Emphasis on the Gulf of Mexico.
  - Multi-Disciplinary Investigation of Sediment Stability & Mass Wasting.
    - Conventional and Deep-Tow MCS
    - Direct Sampling (Geochemistry, ***in situ*** Methane Sensing)
    - Remote Sensing (EM, Heatflow,Fluid Flux)
    - Laboratory Investigation of Fine-Scale Structures (NMR, Mass Spec)
  - Develop Remote Sensing Techniques to Quantify Concentration & Distribution of gas Hydrates.